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First results with non-irradiated and heavily irradiated microstrip trenched detectors

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CNM

Guilio Pellegrini et al

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•Detector designs

•TCAD simulations

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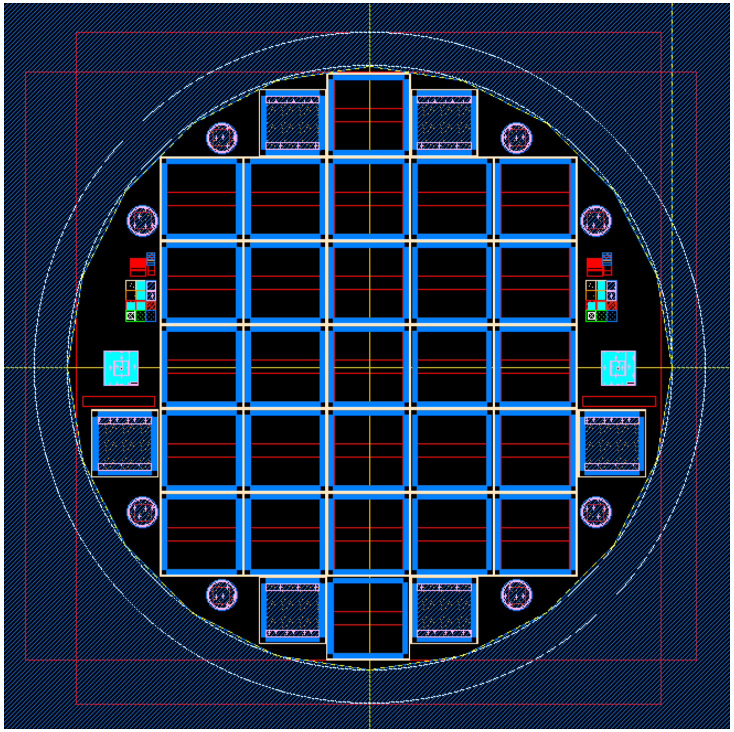


Motivation

Project: fabricate a p-type strip detector with small gain -> Similar signal before and after irradiation

- Multiplication occurs at low bias voltage
- Gain should be limited between 2 and 10:

- Avoid Crosstalk
- Avoid exceeding the dynamic range of readout electronics

- Capacitance should not increase significantly

- Higher capacitance -> Higher noise

You may remember Guilio Giving a presentation on these sensors at 17th RD50 workshop

TCAD simulations done by Pablo Fernánde at CNM

Many thanks to all there Hard work on simulation and Fabrication

Basic detector information

NinP type strip detectors with trenched electrodes

Single chip - 1cm^2 area

Strip pitch 80um with p-stop isolation structures

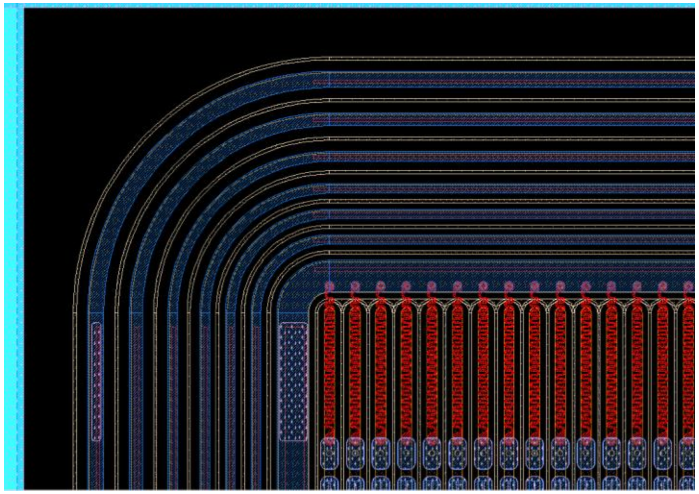
Device Simulation and fabricated done by CNM

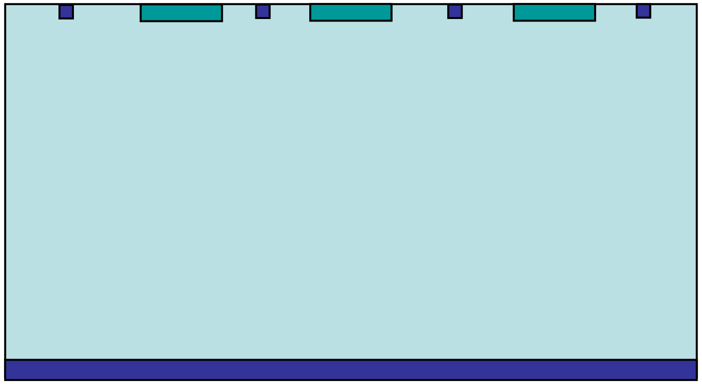
6 Guard Ring structure used, proved operation at 1000v

AC coupled

1 standard P-stop design used a reference

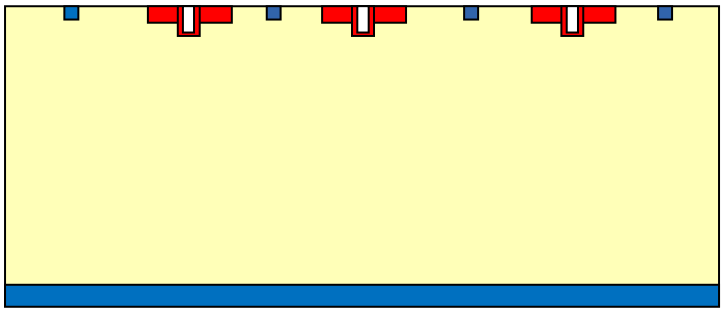
5 trench structures simulated → Fabricated → Measured





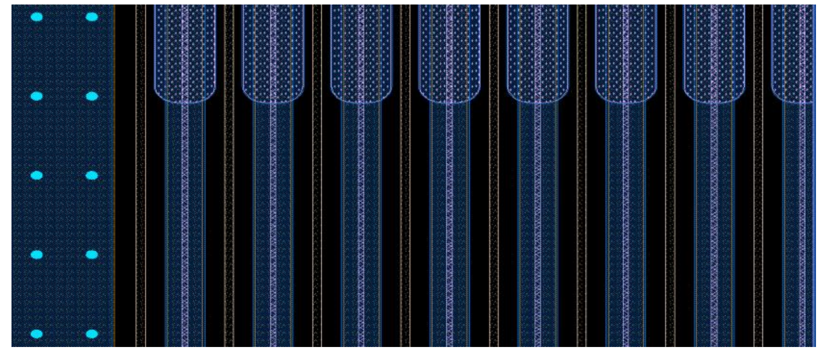
Trenched detector design

Poly trench



Trench 5, 10 50um deep

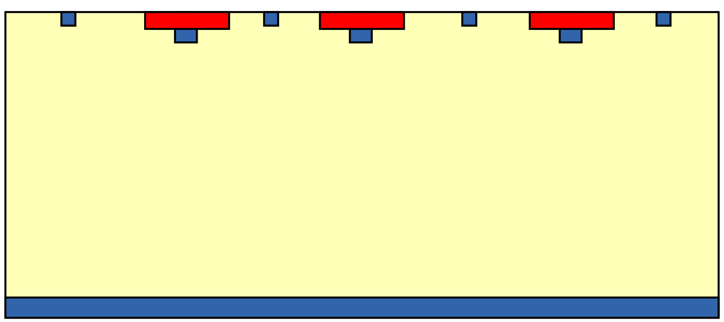
All 5um wide in center of N+ electrode



P+ implant under N electrode

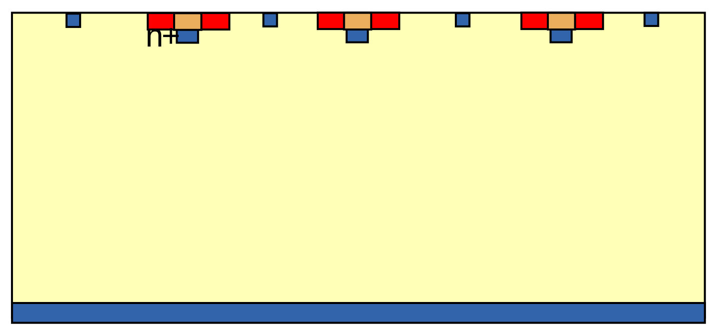
Centered, 5um wide

P-type diffusion



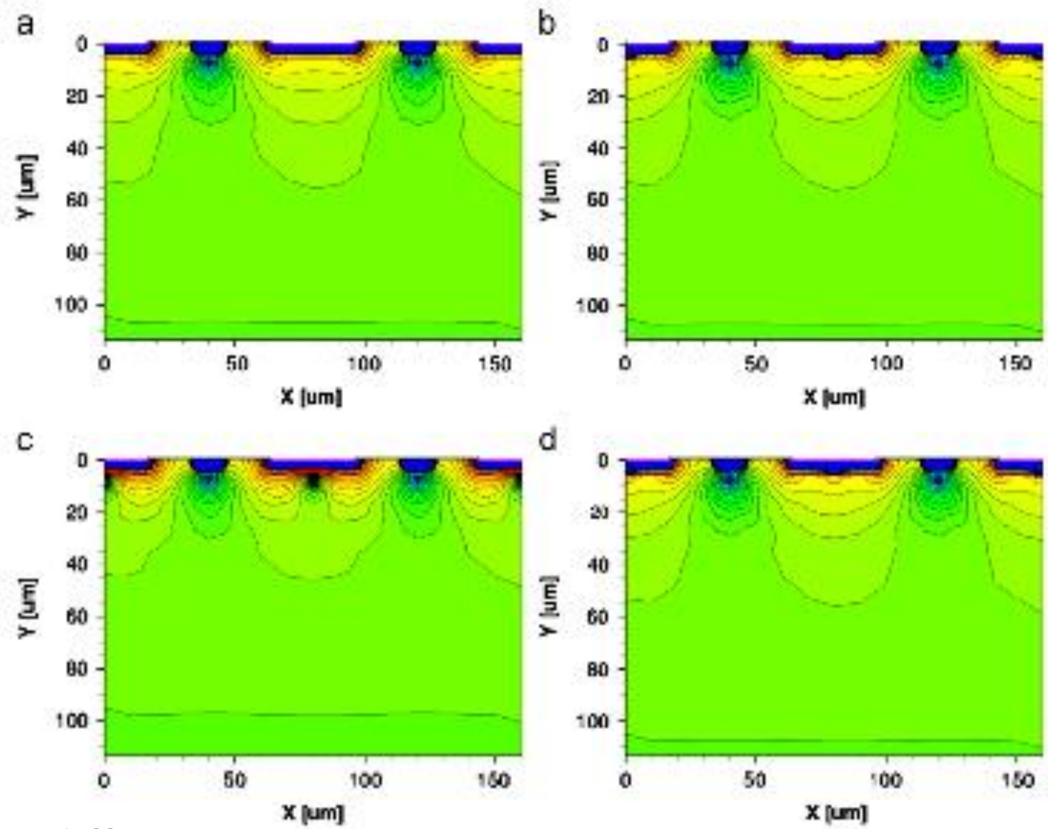
Same as P-type diffusion but with trench through N+

Oxide trench



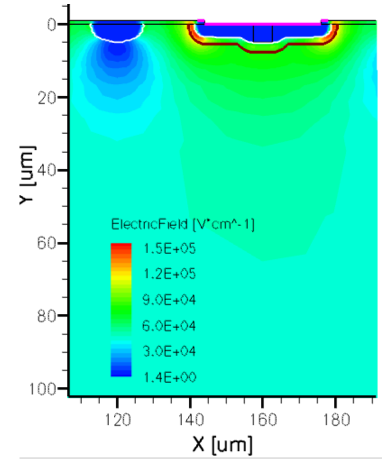
TCAD simulations

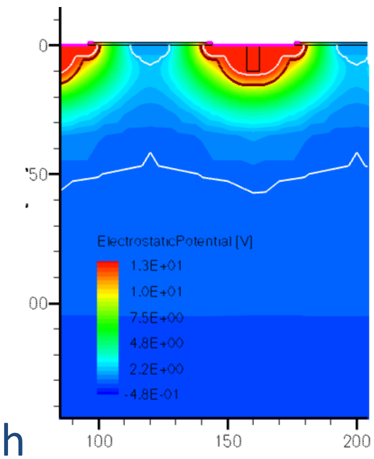
Reference trenched



P+ diffusion

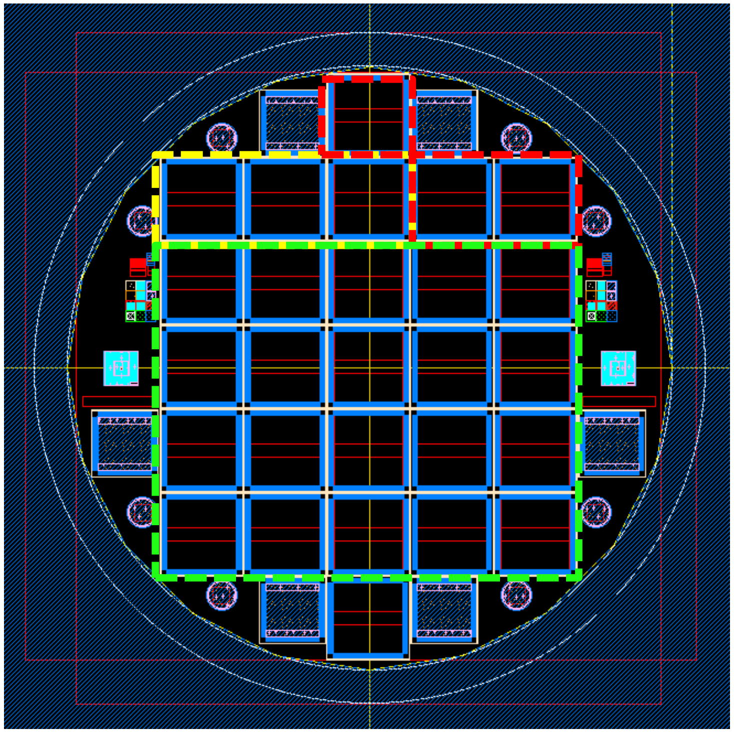
P+ diffusion with oxide filled trench





See NIMA53508 - Simulation of new p-type strip detectors with trench to enhance the charge multiplication effect in the n-type electrodes, P. Fernández-Martínez et al

Design Variation's

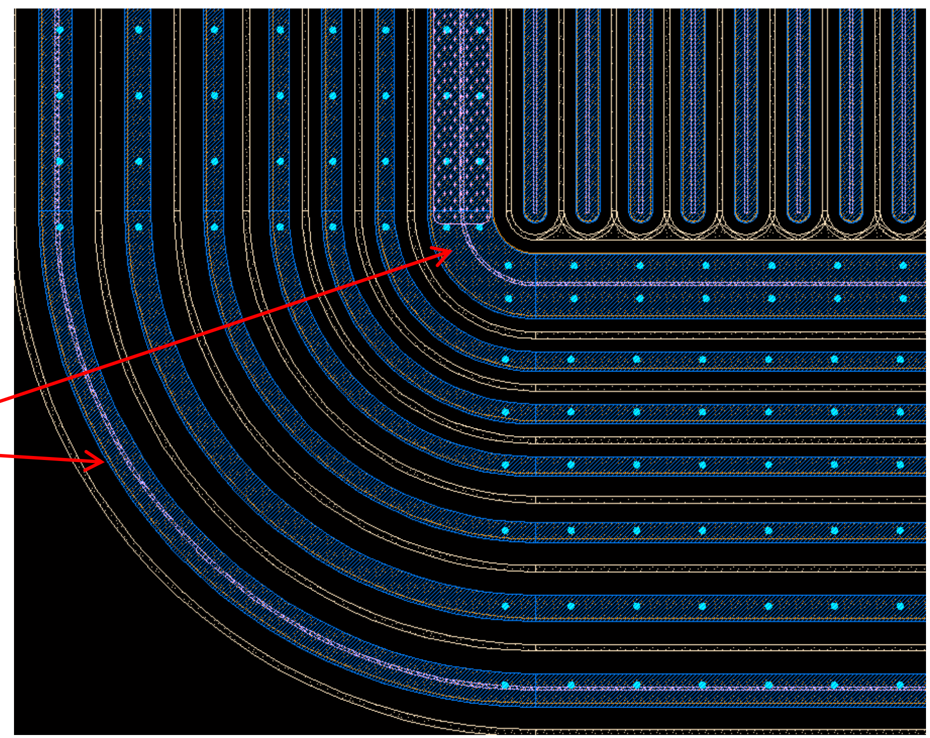


Each wafer featured a couple of variations on trench placement

Det A1- trench structure only in active strips

Det A2 – trench structure extended to Bias rail

Det A3 – trench structure extended to Bias rail and last GR



Trench, Bias ring and final GR

Note, Only type A1 dets sent for irradiation

Wafer information/ Irradiation

Waffers received from CNM:

W2 – 5um trench through center of electrodes
W3 – 10um trench through center of electrodes
W5 – 50um trench through center of electrodes (poor metalisation)
W7 – reference, standard N electrodes with P-stops
W16 – P+ implant under N electrode, 5um wide
W18 – W16 structure with 5um deep and wide through N electrode

Detectors sent for neutron irradiation, Doses -

1E15	1MeV neq	Measured
5E15	1MeV neq	Measured
1E16	1MeV neq	Partially Measured
2E16	1MeV neq	Measured
3E16	1MeV neq	W2/5 No signal at 1000v

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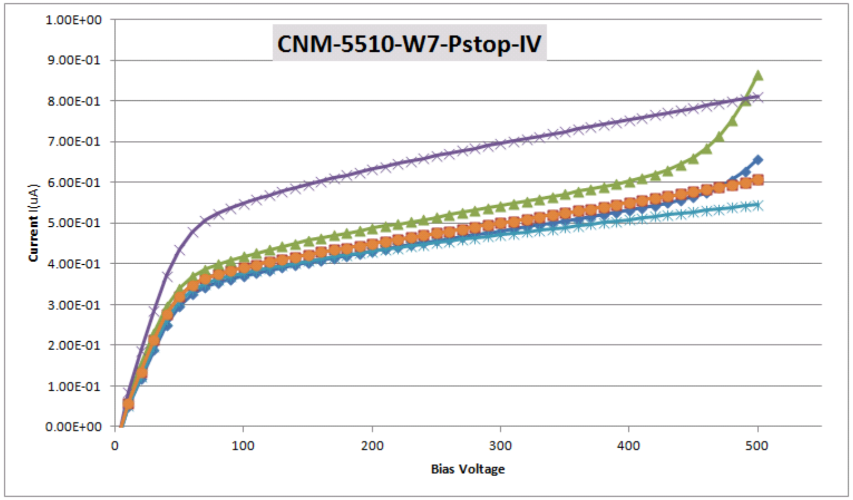
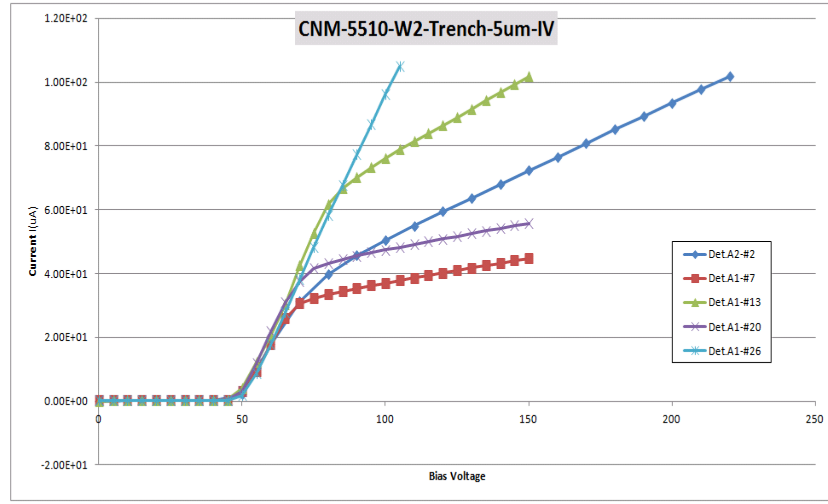
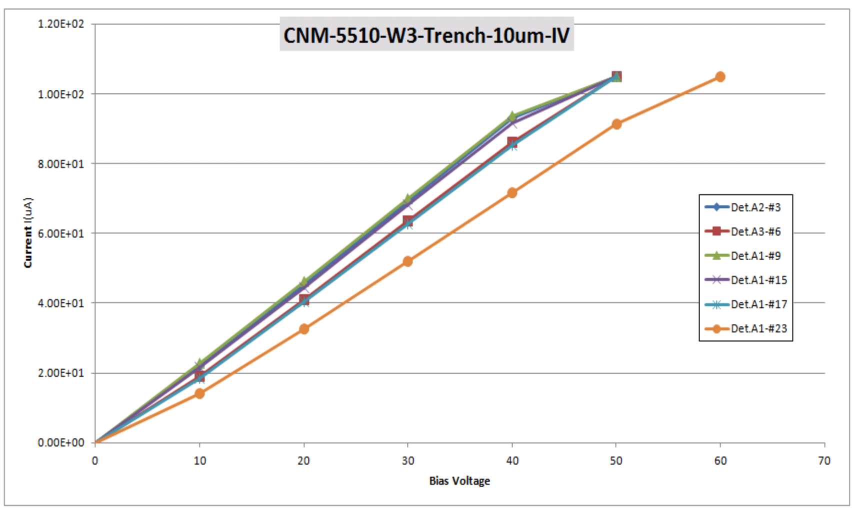
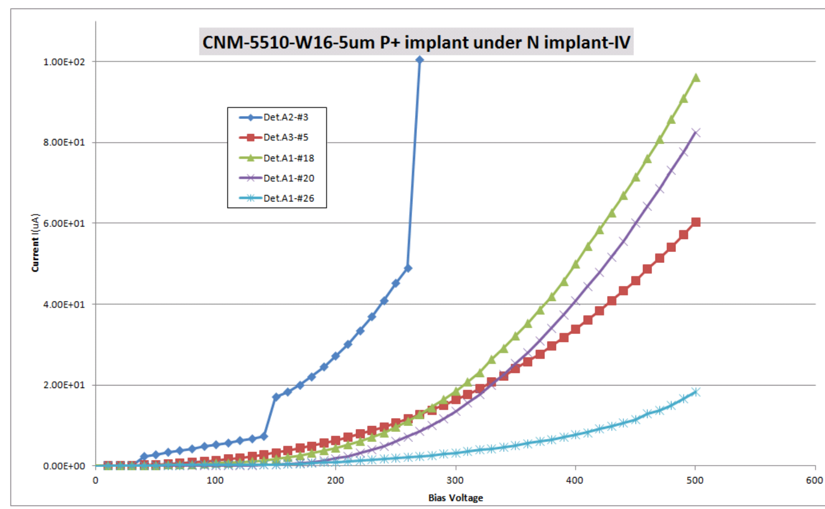
Initial IV from wafers W2,3,7,16









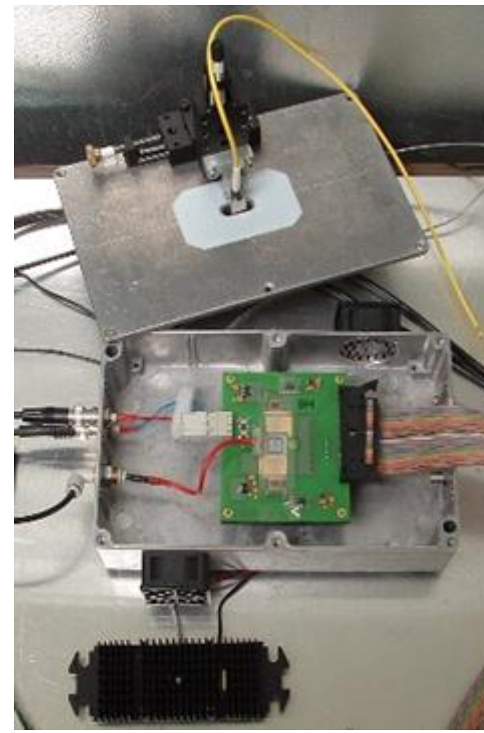
Alibava Setup

Analogue readout based on the Beetle V1.5 chip
(40 MHz readout speed)

Detector attached to aluminium heat sink and cooled using fans to blow cold air over/under detector

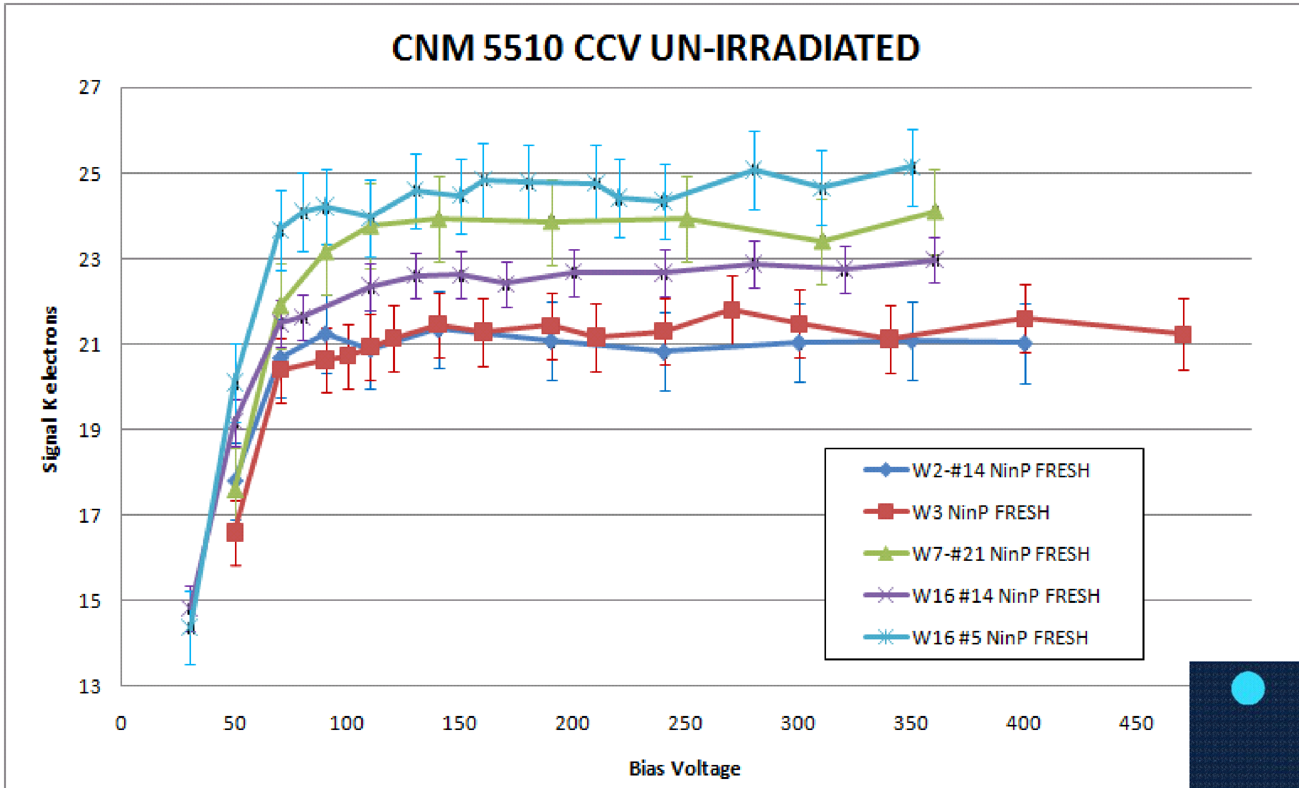
Cooling down to - 45 deg.C (ElCold EL11LT), 1deg.C hysteresis loop

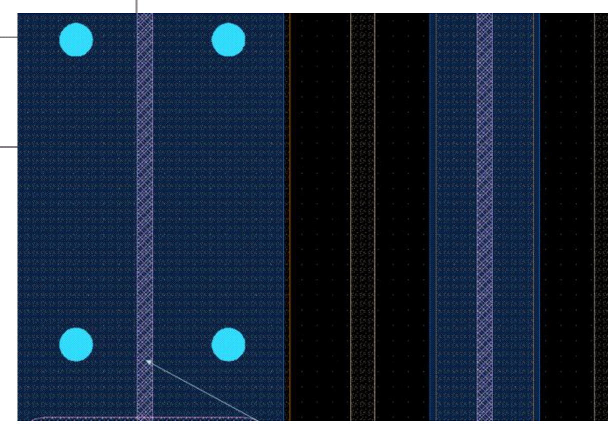
Signal generation with 370 Mbq 90Sr fast beta source or IR Laser (980/1060 nm) for charge collection & sharing studies



Scintilator/s placed under/ontop daughter board for single or coincidence trigger

Un-irradiated CCV

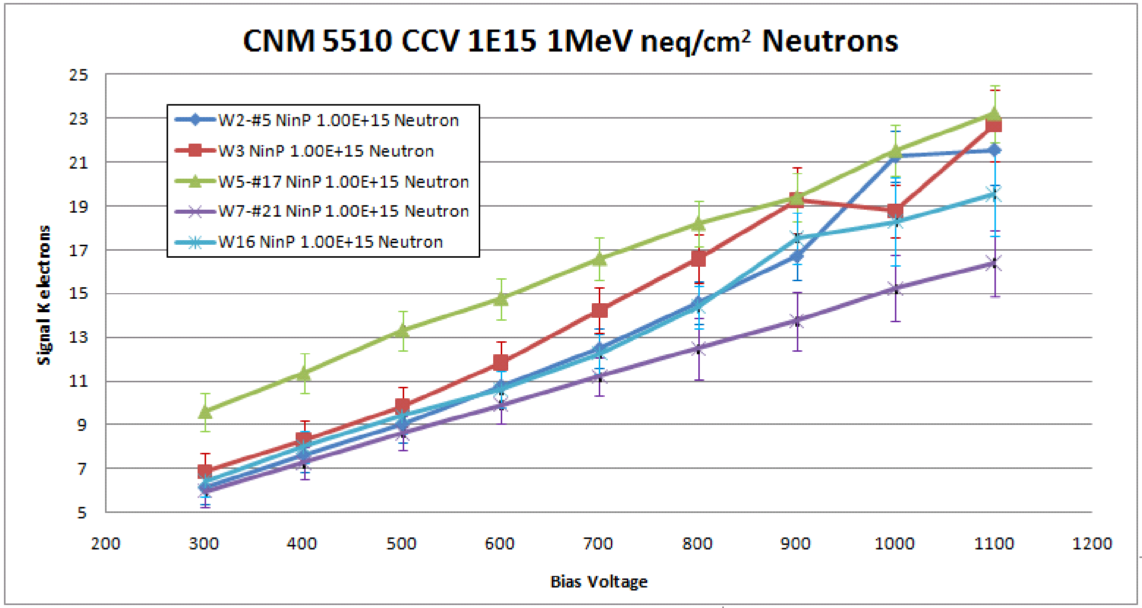




W5 wouldn't Bias, >1ma at 10v

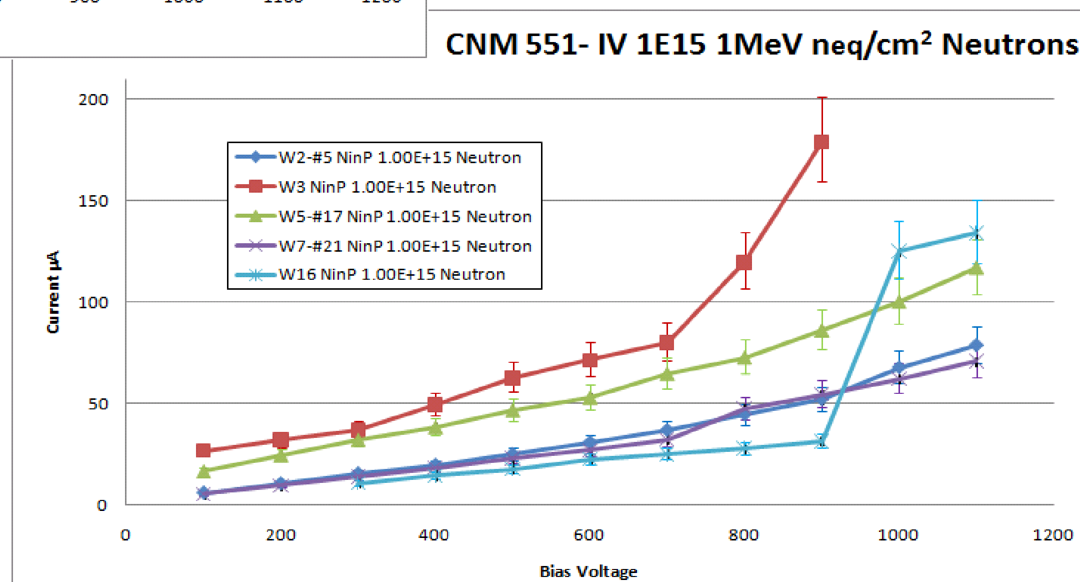
W16 (lightblue), electrode structure extended to Bias Rail

CCV/IV @1E15n



W16 showing growth of CC at higher Voltages

Deeper trench's collect more charge

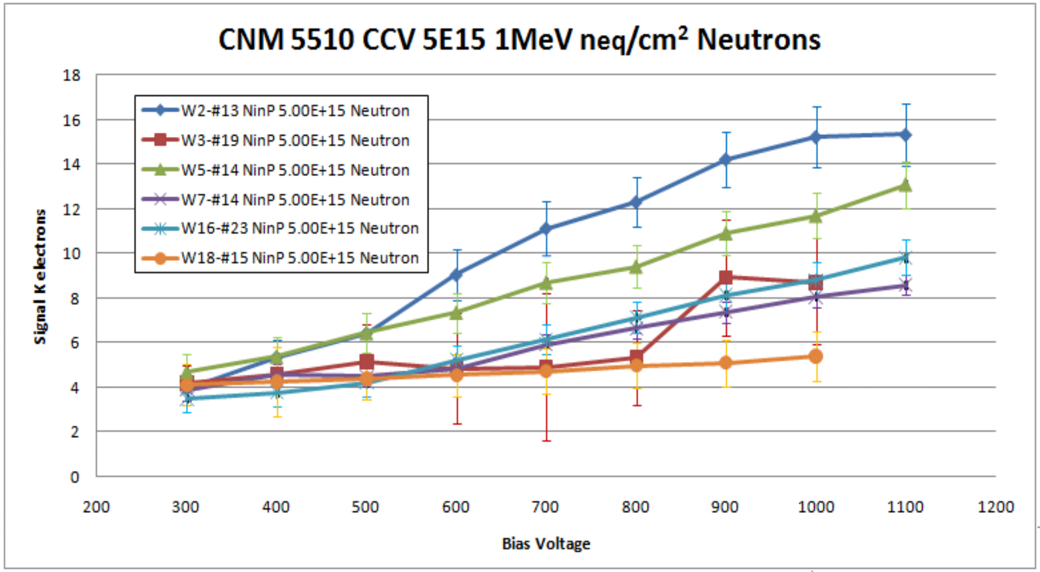


Currents fairly similar

Not too high

High W3 current most probably due to self heating at high V

CCV/IV @5E15n

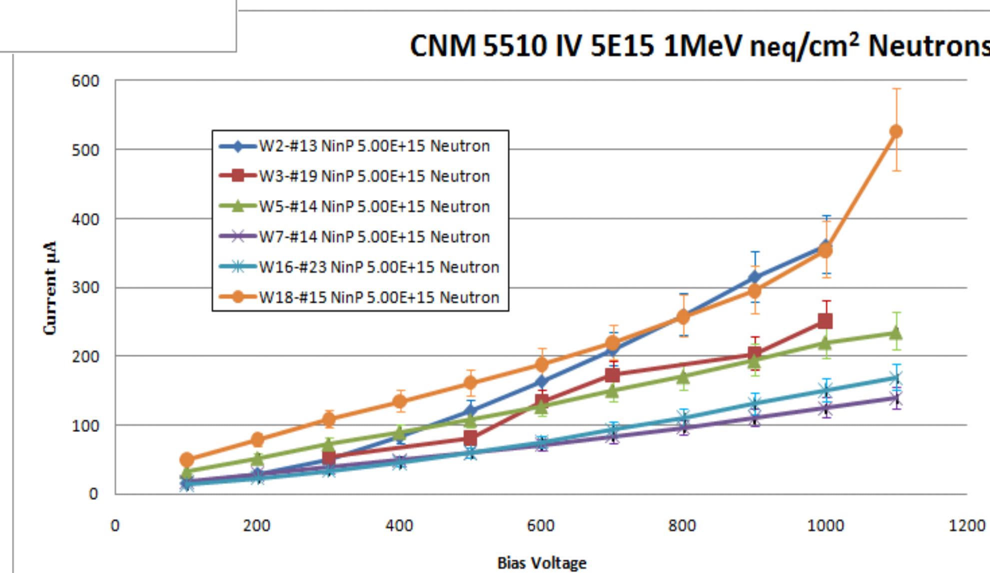


W18 Working!! But Higher current

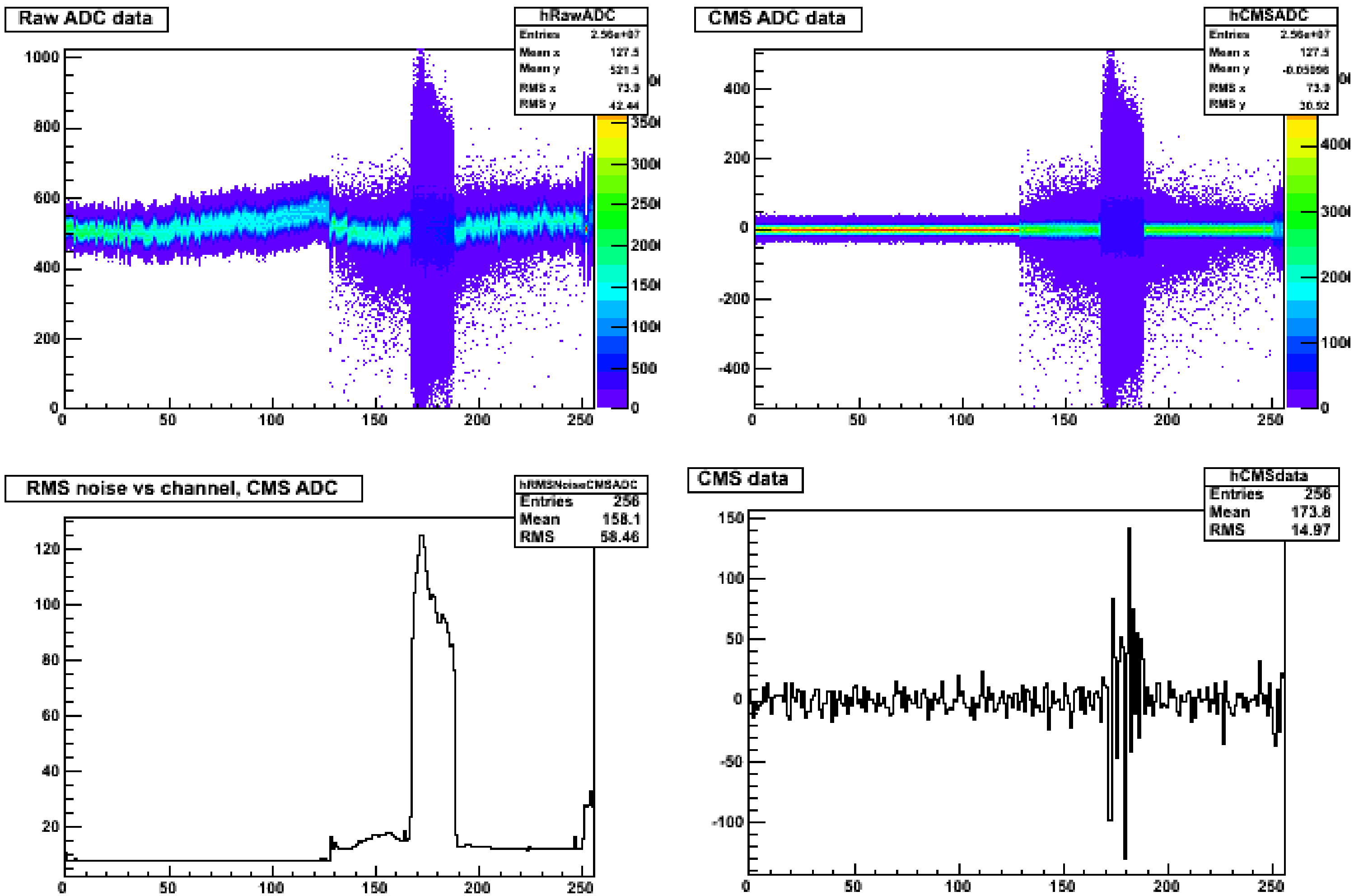
Trenched dets have enhanced CC compared to reference

P+ Diffusion slight increase on CC

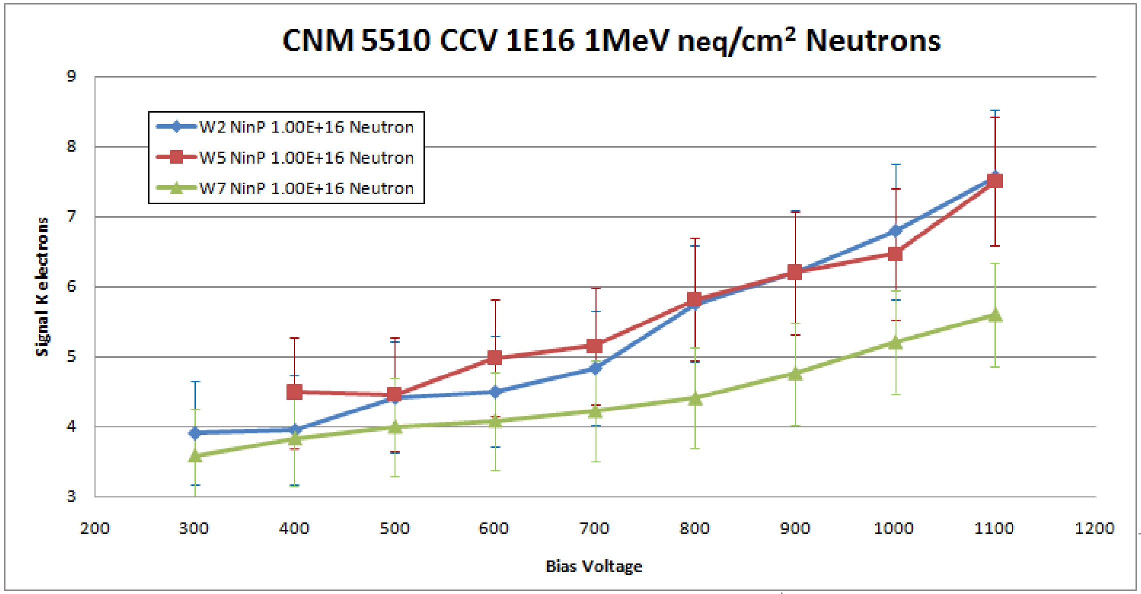
All det designs have higher currents than reference >800v



Cross talk issues



CCV/IV @1E16n

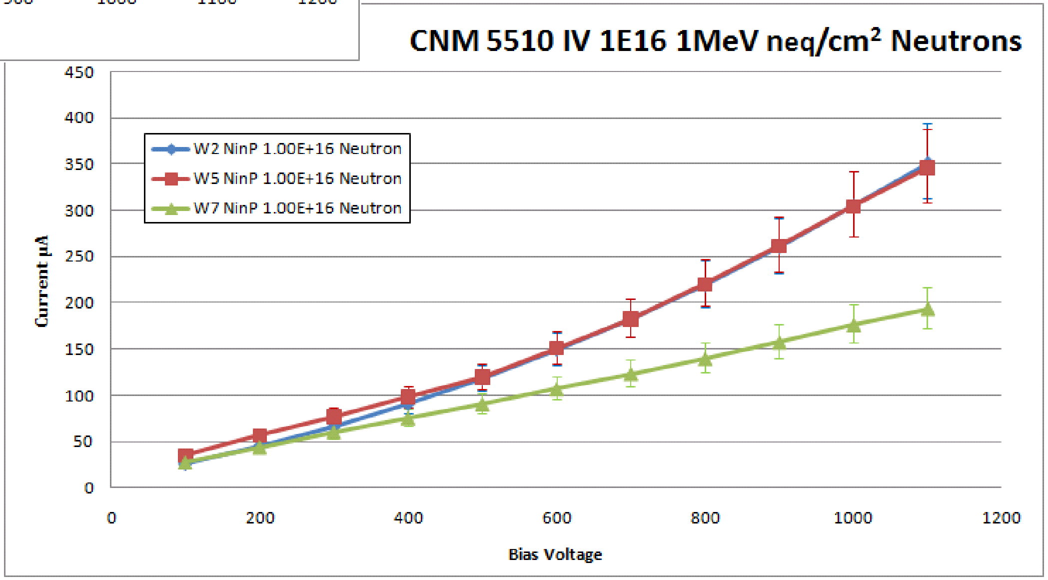


Partially measured

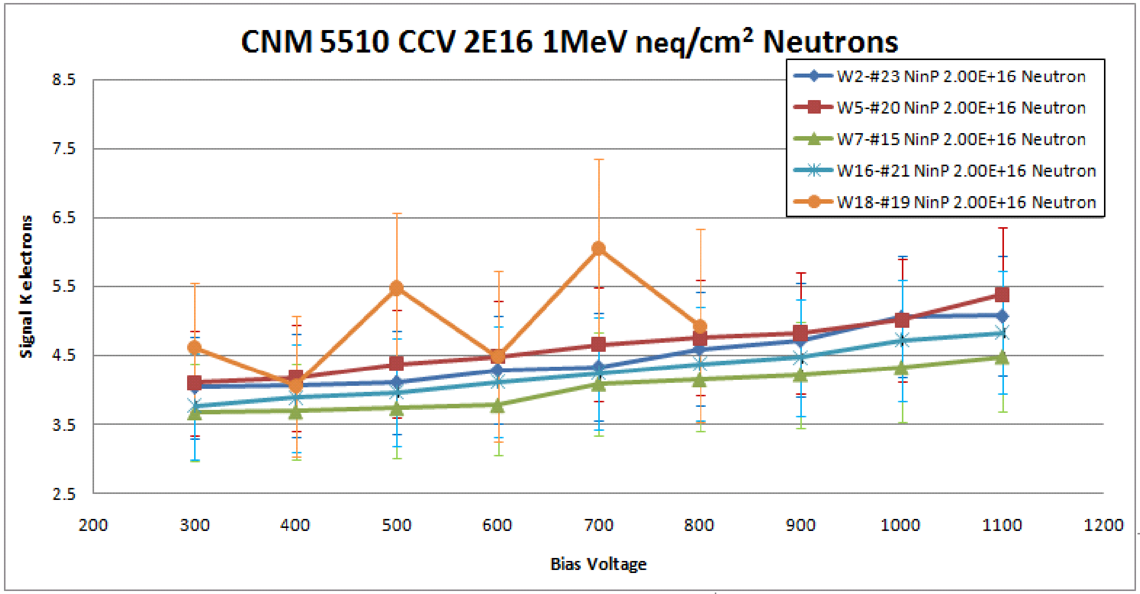
Intersection point for W2 and W5 performance

Higher bias voltages past 500v start to see significant increases in Current

Currents values ok, no sign of thermal runaway at this high dose



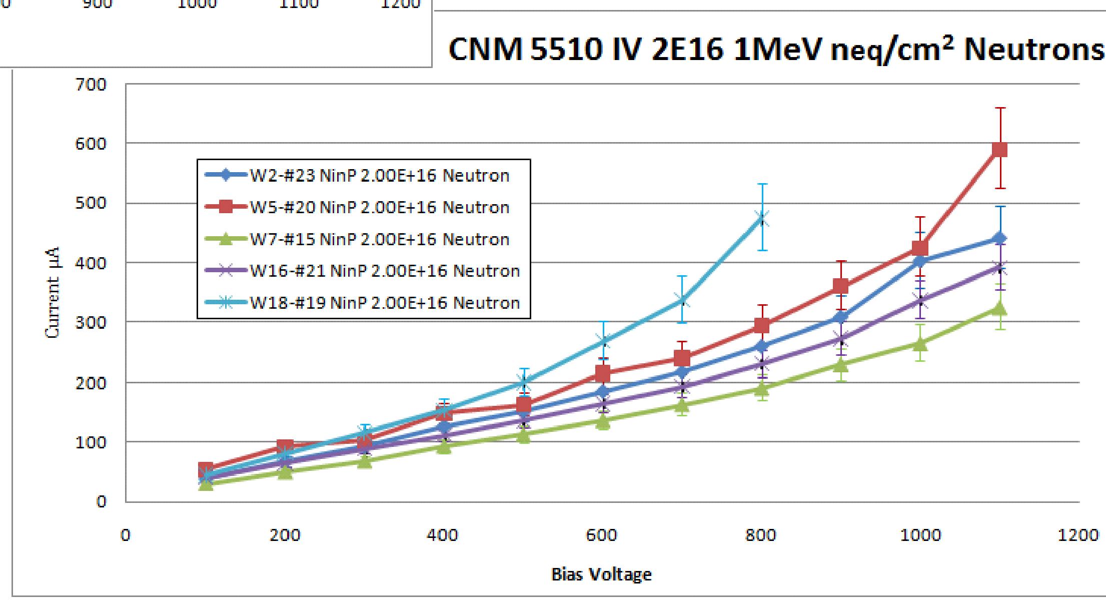
CCV/IV @2E16n



W18 clearly broken, coupling of channels at odd voltages

Other designs above reference

Deeper trench's have larger CC enhancement



Currents (except for W18) not bad given radical design

W16 Very promising for thin detectors at high fluences

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Conclusion

W16 –(P diffusion) Shows only small gains in multiplication, Design more suited to thinner detectors, able to make thinner detectors with higher charge collection

W2 – (5um trench) higher CC therefore multiplication seen in all neutron does shown, very good CC even at 1E16 neutrons.

W5 – (50um trench) Higher CC at all dose’s most promising design after irradiation, does not work before irradiation

W3 – (10um trench) good CC @1E15 but higher currents than other designs

W18 – (P diffusion + oxide filled trench) poor performance at all dose’s with respect to CC and IV.

ALL designs have cross talk problems at high Neutron dose and Bias Voltage

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Thank you for your attention

Any Questions?